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Physics Department

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Sheet 3

Waves (16.4-5), Sound Waves (17.1-3)

Reflection and transmission

Q1: *A heavy and a light rope a tied together and set under tension. A pulse is send down from the end of the heavy rope. From the connection point two pulses will travel. Which one is faster?*

Energy transmission

P1. Imagine you want to send a wave down a stretched string which has a mass density of 40 g/m. You will use a small motor in order to move one end of the string up and down in a sinusoidal fashion. The string is under a tension of 100 N. To move the rope up and down faster or with larger amplitude will require a higher power from the motor. If the maximum power of the motor is 300 W, what will be the maximum amplitude one can achieve at a frequency of 50 Hz?

Sound

P2. A loudspeaker vibrates at the frequency f=4.4 kHz with an amplitude A=0.1μm and emits sound waves into a tube.

a. What is the wavelength λ of the sound wave at an air temperature of T=25 °C?
b. What is the angular wave number k in the unit cm^{-1} of this wave? How many pressure maxima are contained in the length l=1.5 m?
c. What are the pressure and displacement amplitudes of that sound wave?
d. The frequency of the loudspeaker is now changed to f_1=440Hz, which is the frequency of the concert pitch, i.e. the reference tone a^1 for the tuning of musical instruments (often, the tone you hear on a telephone line which announces a free line or the occupied signal is a^1). What is the wavelength λ of a^1 at T=25 °C? What is the relative change (in percent) of λ if T is lowered to 0 °C? Does λ increase or decrease?
e. Discuss the relation of the size of musical instruments and the tone heights they play.

P3. Ultrasonic pulses at a frequency of 25 MHz are used to determine the distance to a building. At a temperature of 30 ° C theses pulses needed 60 ms between sending the pulse and receiving the echo by the measuring device. How far is the building and what is the wavelength of theses sound waves in air?

P4. A sound wave travelling along a medium is described by the displacement function

$$S(x,t) = (0.20\,\mu m)\cdot \sin\left[12\,\frac{x}{\mathrm{m}} - 5000\,\frac{t}{\mathrm{s}}\right]$$

a. Determine the displacement amplitude, the frequency and the speed of these sound waves.
b. If the density of the medium is 2 Kg/m^3, determine the pressure amplitude and write down the pressure changes as a function of time and position.
c. Determine the Bulk modulus of the medium.

P5. Three noise sources produce intensity levels of 70dB, 73 dB and 80 dB, respectively, when acting separately. When the sources act together, their intensities add. Find the sound level (in dB) and the intensity (in W/m^2) when the three sources act at the same time.